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REPORT NO. 55A 4173

DATE 19 March 1965

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GENERAL DYNAMICS | ASTRONAUTICS

CENTAUR/SURVEYOR

SEPARATION

SYSTEM VALIDATION TEST

REPORT NUMBER 55A 4173

under NAS 3-3232

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INTRODUCTION:

This phase of testing consisted of two test runs, performed to evaluate the 55-71190 Centaur/Surveyor "Pin-Puller" Separation System under simulated zero-gravity conditions.

Two test phases were performed previously using the 55-71155 and 55-71187 Separation Latches. Test results for these tests are given in Engineering Test Reports 55B 2589-1 and 55B 2589-2.

OBJECTIVE:

The primary objective of this test phase was to verify proper functioning of the 55-71190 Centaur/Surveyor Separation-Jettison System under conditions of simulated zero-gravity. Detailed test objectives were as follows:

1. Measure pitch and yaw imparted to the spacecraft by the separation system during jettison.
2. Determine the nominal axial separation velocity imparted to the spacecraft by the separation system.
3. Measure jettison spring extension versus time, at all three spring locations.
4. Demonstrate the ability of the 55-71190 separation latch configuration to satisfactorily release the spacecraft.

CONCLUSIONS:

The 55-71190 Centaur/Surveyor "Pin-Puller Configuration" Separation-Jettison system functioned satisfactorily under conditions of simulated zero gravity, with pretension loading of 2000 pounds at each fitting.

RECOMMENDATIONS:

During test preparation, certain difficulties were encountered with installation of the 55-71190 latches. These difficulties were not related to the functional integrity of the latch installation. They are summarized as follows:

RECOMMENDATIONS: (Continued)

1. Latch Installation.

- (a) The 55-71141 Payload Adapter rivet head clearance was marginal for proper positioning of the 55-71193-7 Filler (the filler was not identified or referenced on the 55-71190 Latch Installation Drawing). The test installation at one latch could not be accomplished without first removing a portion of some rivet heads. This condition could possibly be improved if the overall width dimension of the filler was reduced.

2. Strain Gage installation of the 55-71153-7 Clevis.

- (a) A shield or guard would be desirable for this installation. One strain gage was damaged during preparations for Test Run Number One, despite cautious handling.
- (b) The relief which was cut in the 55-71175 Barrel for the strain gage lead wire had a sharp edge. A radius at this relief might reduce the possibility of damage to the strain gage leads due to chafing.

3. Conax Latch Pin installation.

- (a) The 55-71190-7 Shim was too thick for precise positioning of the 84-89950-002 Latch Pins. Each shim caused a rotation of approximately 60° in the positioning of the latch pin squib parts. There was no indication on the drawing of a maximum number of shims allowable per installation. In order to accomplish the test installation, supplementary shim material was used. A shim washer fabricated from a laminated material might be considered which could be "peeled" in small increments to the required thickness.

TEST FIXTURE:

The basic test fixture consisted of a heavy steel frame structure measuring approximately fifteen feet high, sixteen feet wide, and ten feet deep. This fixture served as a rigid mounting base for supporting (1) a 1.25 inch thick aluminum back-plate on which the payload adapter assembly was mounted; (2) a special air suspension assembly from which the spacecraft was suspended.

The air suspension assembly consisted of an air-bearing scooter and an air-spring suspension cylinder. The air-bearing scooter rode on a machined steel plate mounted to the top of the test fixture, with provision for precision leveling. The scooter and plate served as a near-frictionless pneumatic bearing, supporting the weight of the spacecraft on a film of high pressure air. It provided +3 inches of lateral movement and thirty inches of longitudinal movement. The air-spring cylinder was suspended vertically from the scooter, providing a precision pneumatic counterbalance for the spacecraft weight and providing +3 inches of vertical spacecraft movement as well as near-frictionless rotation about the cylinder axis. The spring constant of the air-spring cylinder was approximately 5 pounds per inch. The spacecraft mass model was suspended by two knife-edge bearings which were mounted in a yoke attached to the air-spring cylinder, see Figure 9. In summary, lateral and longitudinal freedom of spacecraft motion were provided by the air-bearing scooter. Vertical freedom was provided by the air-spring cylinder. Pitch and yaw freedom were provided by the knife-edge bearings and rotation of the air-spring cylinder piston in its air-bearing journal.

A steel tower approximately twelve feet high was mounted on top of the test fixture over the air-bearing scooter assembly, to support pneumatic supply lines and minimize effects of these lines on scooter movement. The test fixture was partially enclosed to keep out air currents.

TEST SPECIMEN:

The assemblies and installations making up the test specimen are identified as follows:

<u>TITLE</u>	<u>DRAWING NUMBER</u>
Spacecraft Adapter Installation-Aft, Centaur/Surveyor	55-71145
Spacecraft Adapter Installation-Forward, Centaur/Surveyor	55-71141
Latch Installation- Separation, Surveyor	55-71190 (Figures 16 through 19)
Conax Latch Pin	1808010-02
Conax Explosive Squib	1621-033-01
Spring (Jettison) Assembly, Surveyor	55-46063
Mass Simulation Surveyor Payload	55-71177

The spacecraft mass model was modified for this test as follows:

1. Knife-edges were installed on the four inch thick plate of the model.
2. Extensions were welded to the latch mounting plate to provide bearing surfaces for the jettison springs.
3. Steel weights, sufficient to move the model center-of-gravity to the knife-edges, were installed on the back-plate of the model. Total weight of the model as used was 2268 pounds, compared to 2111.25 pounds for the Hughes T-1 Surveyor Test Vehicle used in previous tests.

No attempt was made to duplicate a flight electrical system. One explosive squib at each latch was fired by a 28 volt direct current power supply.

TEST INSTRUMENTATION:

Due to the expedited nature of this test, instrumentation was minimized. Instrumentation provided for this phase of testing is described below.

1. Jettison Spring Piston Displacement During the Jettison Sequence: Lockheed WR-8 linear motion transducers were used to measure this parameter at all three jettison spring locations. The transducer installation is shown in Figure 14. Calibrations were performed by compressing the jettison springs using the tool shown in Figure 15, and recording the resultant recorder galvanometer deflections at known displacement intervals. During the test sequence, the oscillograph recorder was operated at a paper speed of 69 inches per second.
2. Spacecraft Displacement after Separation: A 400 frame per second camera was set up as shown in Figure 11 to record this parameter. Exact frame rate was determined by firing a flash bulb at T-0 and at approximately T+3 seconds. Corresponding events were recorded on the oscillograph recorder to determine the exact time interval between flash bulb events. With this information, exact motion picture frame rates were established. The movie film was viewed on a Vanguard Film Analyzer for final data reduction, and a suitable parallax correction was made.
3. Spacecraft Model Pitch and Yaw: A 400 frame per second camera was set up as shown in Figure 10 to record these parameters. Exact frame rate was determined as in item 2 above. A motion picture target, marked in one-inch squares, was attached to the nose of the spacecraft model. The film used to view the motion of this target during the jettison sequence had a pre-exposed crosshair for use as a reference in determining the amount of pitch and yaw. Data obtained was used to calculate tip-off in degrees.

A third camera was positioned to view one of the latch/spring installations during the jettison sequence, as shown in Figure 12.

TEST PROCEDURE:

The sequence of events used for testing was as follows:

1. Instrumentation was set up and calibrated.

Note: As a part of the calibration procedure, the jettison springs were compressed as shown in Figure 15. Retainers made from 0.50 inch tubing were inserted around the spring pistons to keep the springs compressed during spacecraft mating, as shown in Figure 14.

2. The spacecraft was "floated" on the air-spring cylinder at approximate mating height, and physically mated to the payload adapter.
3. Using a sight level in front of the test fixture, the mated height of the spacecraft was established and recorded. See Figure 10.
4. The spacecraft was manually demated from the payload adapter.
5. The air-spring pneumatic controls were adjusted until the spacecraft was floating at the mating height in a stable condition.
6. The spacecraft model was then mated to the payload adapter, and the pre-compressed jettison springs were freed by removing the retainers mentioned in step one.
7. Each separation latch was torqued to a pre-tension load of 2000 pounds, using a SR-4 strain indicator to read the output of a four arm strain gage at each latch. See Figure 20.
8. The pyrotechnic firing harness was checked for zero-voltage.
9. One live squib and one dummy squib were installed in each latch pin. The firing harness was then connected.
10. After final motion picture setup and test preparation had been completed, the test control automatic sequencer was started. The automatic sequence of events is summarized as follows:

TEST PROCEDURE: (Continued)

T-5 seconds	Automatic sequencer on.
T-2 seconds	Cameras and oscillograph recorder on.
T-0 seconds	Separation Latch pyrotechnic firing circuit energized. Flash bulb event.
T+3 seconds	Flash bulb timing event.
T+5 seconds	All circuits off.

11. The spacecraft was manually restrained after reaching its limit of travel.

TEST RESULTS:

Two test runs were conducted on the Centaur/Surveyor Pin-Puller Configuration Separation System in this test phase. Two previous test phases, using the 55-71155 and 55-71187 Latch Configurations, are described in Engineering Test Reports 55B 2589-1 and 55B 2589-2.

The 55-71190 Latches performed satisfactorily during this test phase. Certain difficulties experienced during installation of the latches are described in the Recommendations Section of this report.

The velocity imparted to the mass model by the separation springs, as measured between one and twenty-four inches of travel, was 0.700 feet per second for Test Run One and 0.685 feet per second for Test Run Two. See Figures 3 and 4.

Figures 5 and 6 show the spacecraft model pitch and yaw versus time. It will be noted that tip-off of the model does not start immediately. This could be due to some flexure in the suspension yoke during separation travel.

Jettison spring displacement versus time is plotted in Figures 1 and 2. Facsimiles of oscillograph data from which these figures were prepared are shown in Figures 7 and 8.

Movie film records of these tests, as described in the Instrumentation Section of this report, are filed in the Motion Picture Film Archives under Test Number 55A 4173-1, Centaur/Surveyor Separation System Validation Test.

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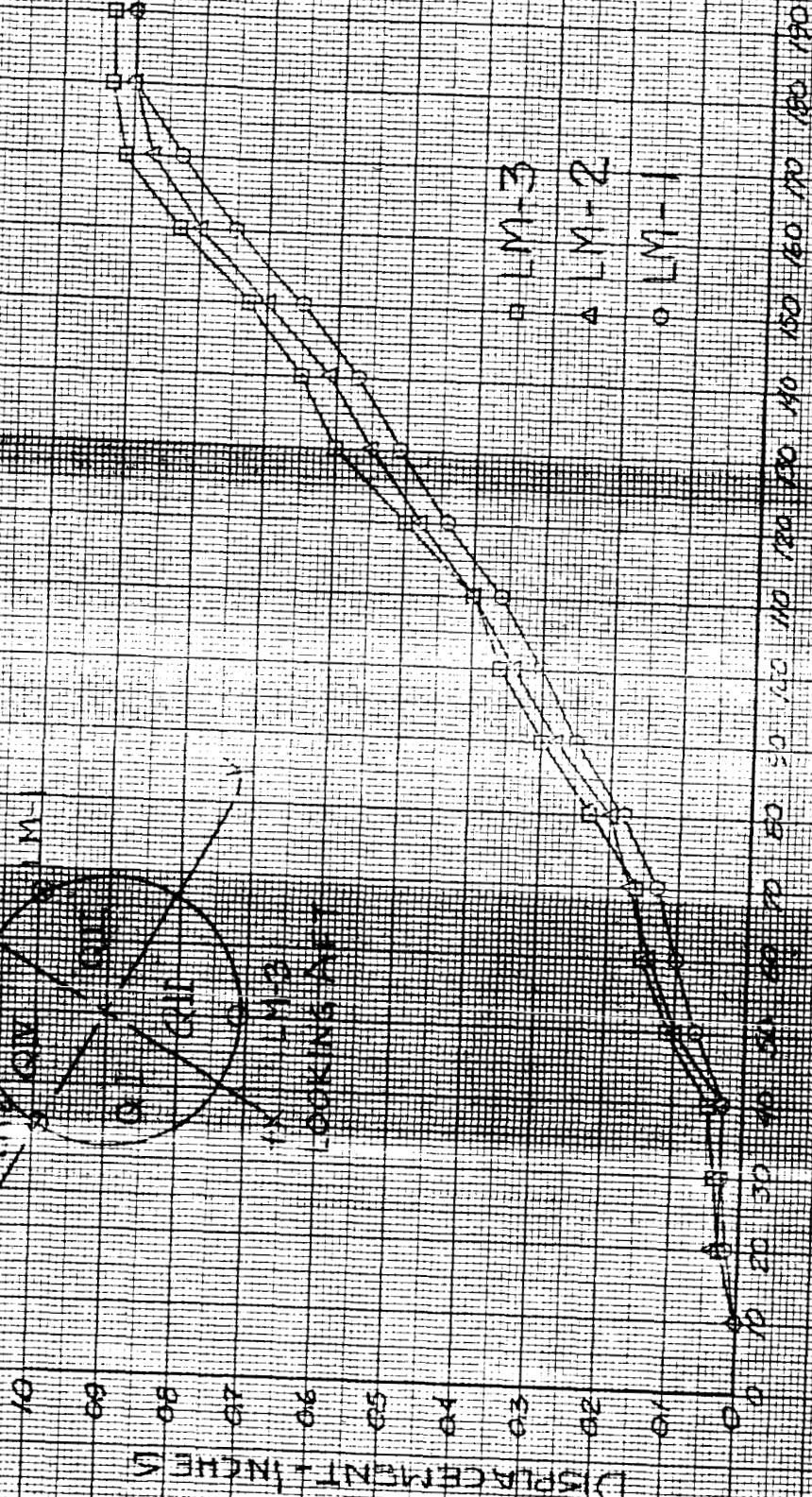
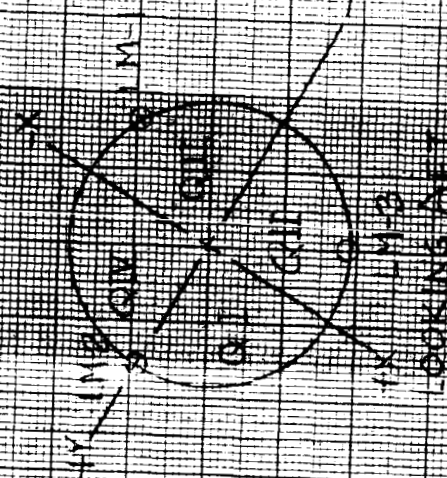
TEST RESULTS: (Continued)

NOTE: Test data from which this report was prepared are recorded in Engineering Test Laboratory Data Books, Numbers 7951, 7982, and 27671.

Date 19 March 1965

JETTISON SPRING DISPLACEMENT VS TIME

RUN NO. 1
FEB 9 1965



TIME - MILLISECONDS

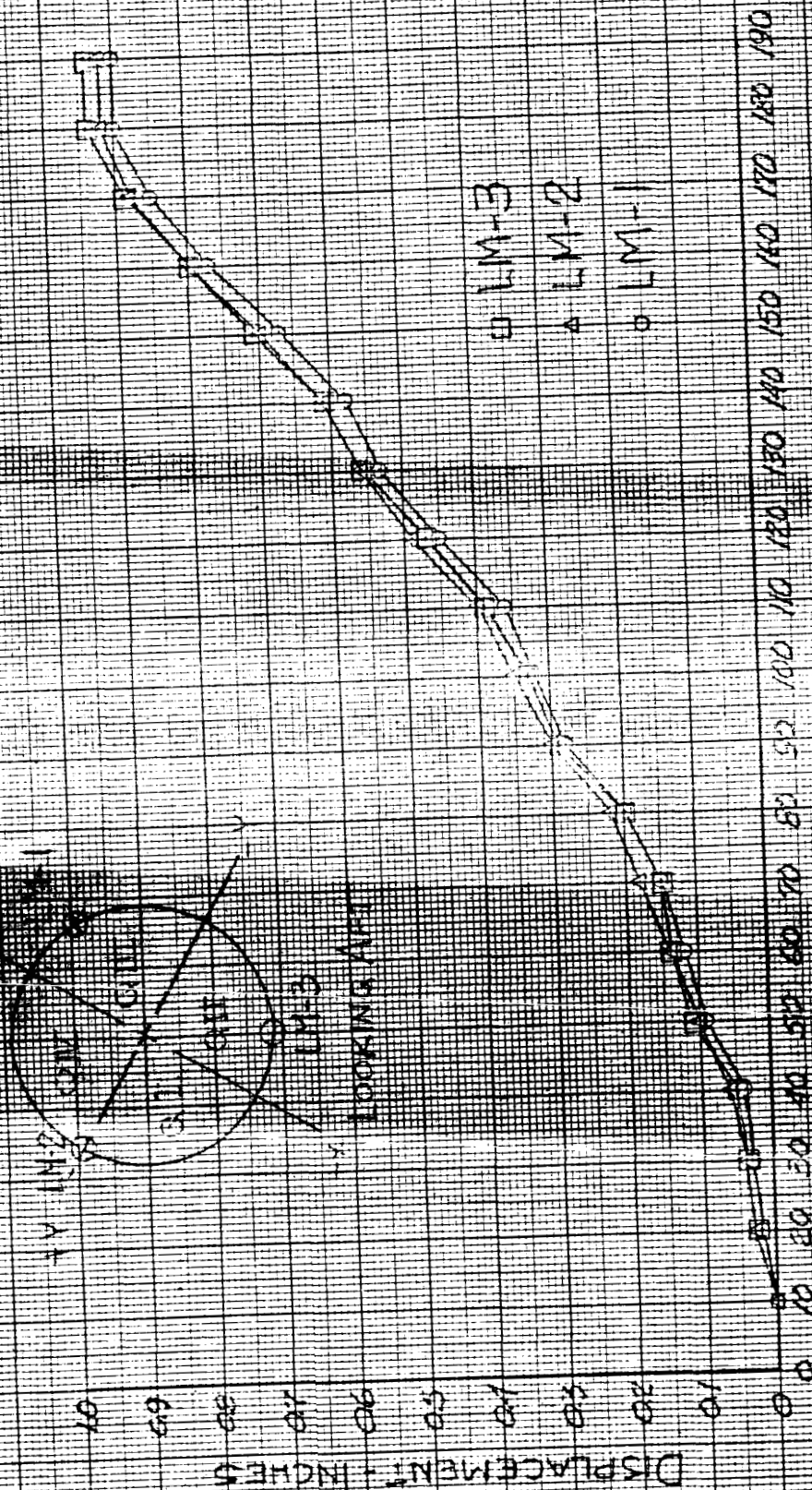
FIGURE 1

2X10 22M 65

JETTISON SPRING DISPLACEMENT vs TIME

RUN NO 2

FEBRUARY 1965



TIME - MILLISECONDS

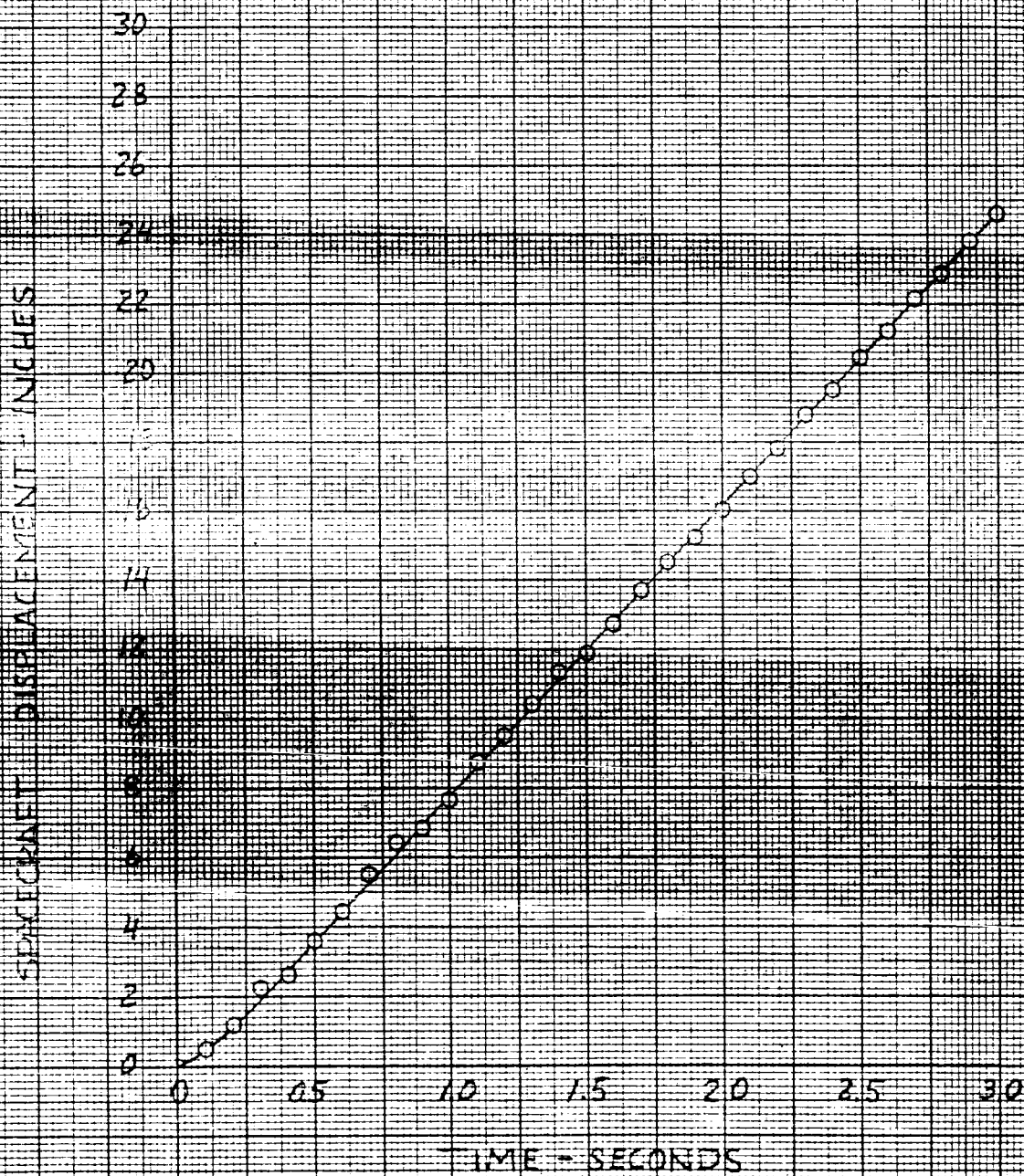
FIGURE 2

22-2-65

SURVEYOR SEPARATION TEST

SEPARATION DISPLACEMENT

RUN No 1 TEST DATE 2-9-65



817 2-9-65

FIGURE 3

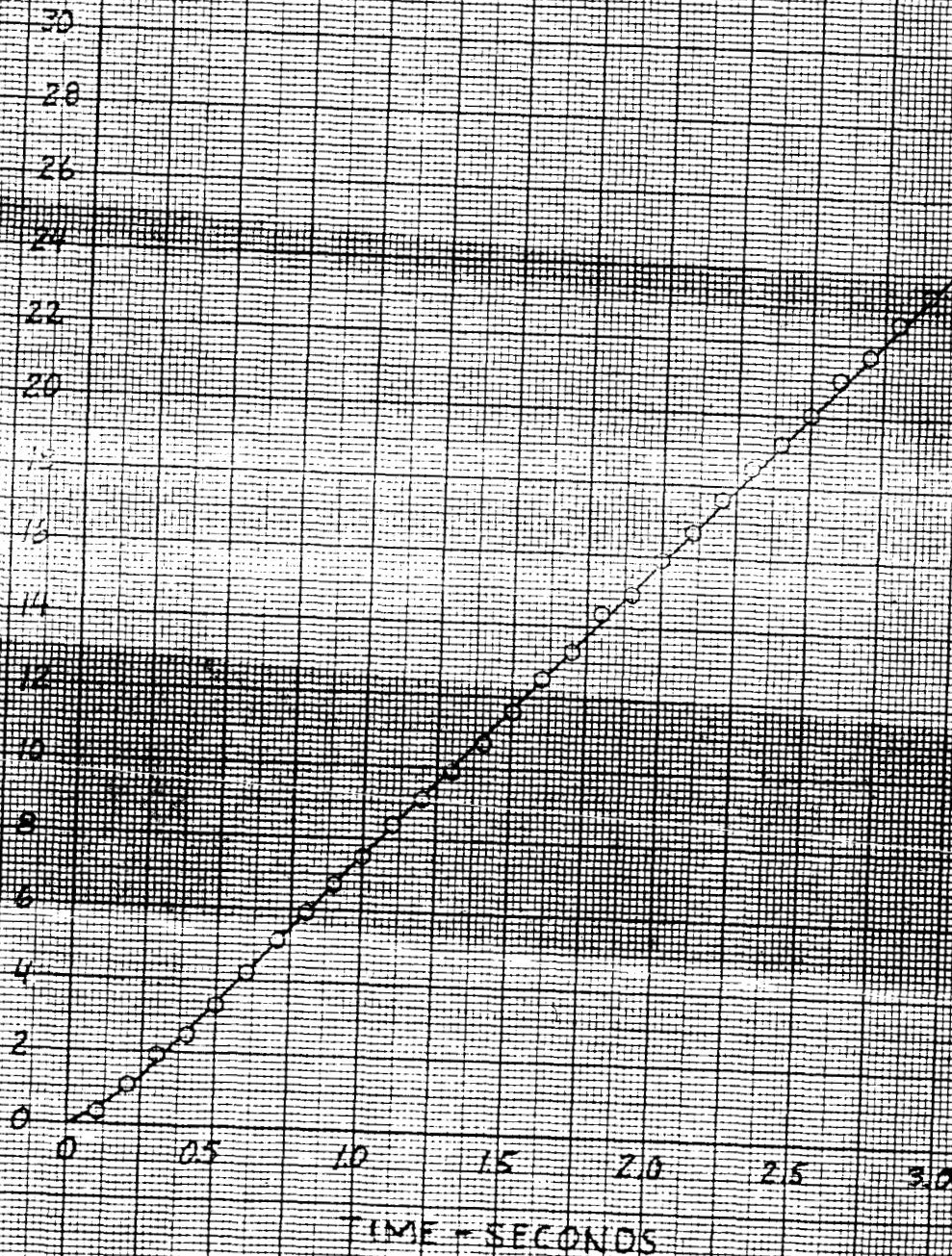
Date 19 March 1965

SURVEYOR SEPARATION TEST

SEPARATION DISPLACEMENT

RUN No 2 TEST DATE 2-11-65

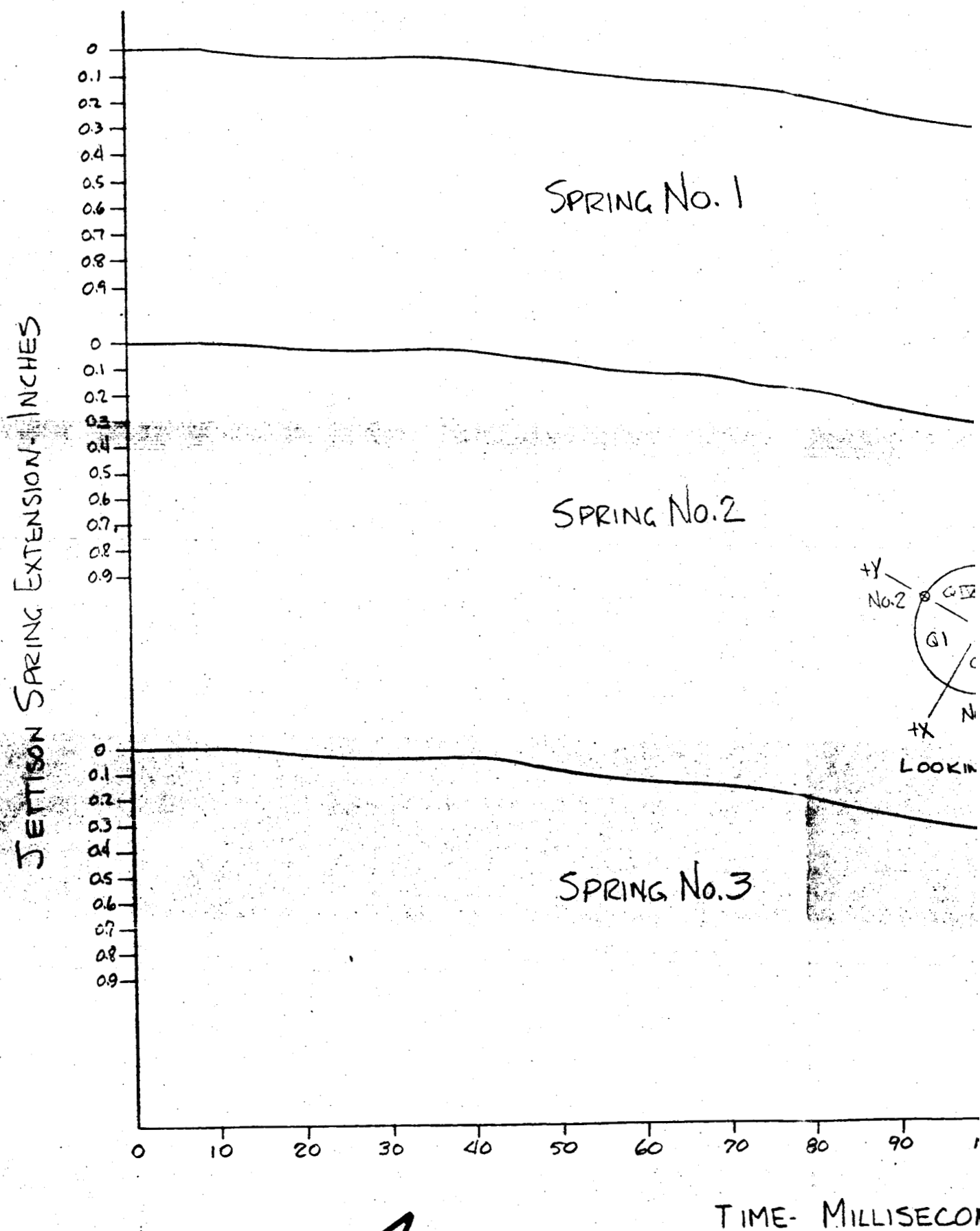
SEPARATION DISPLACEMENT - INCHES



8/1 2-17-65

FIGURE 4

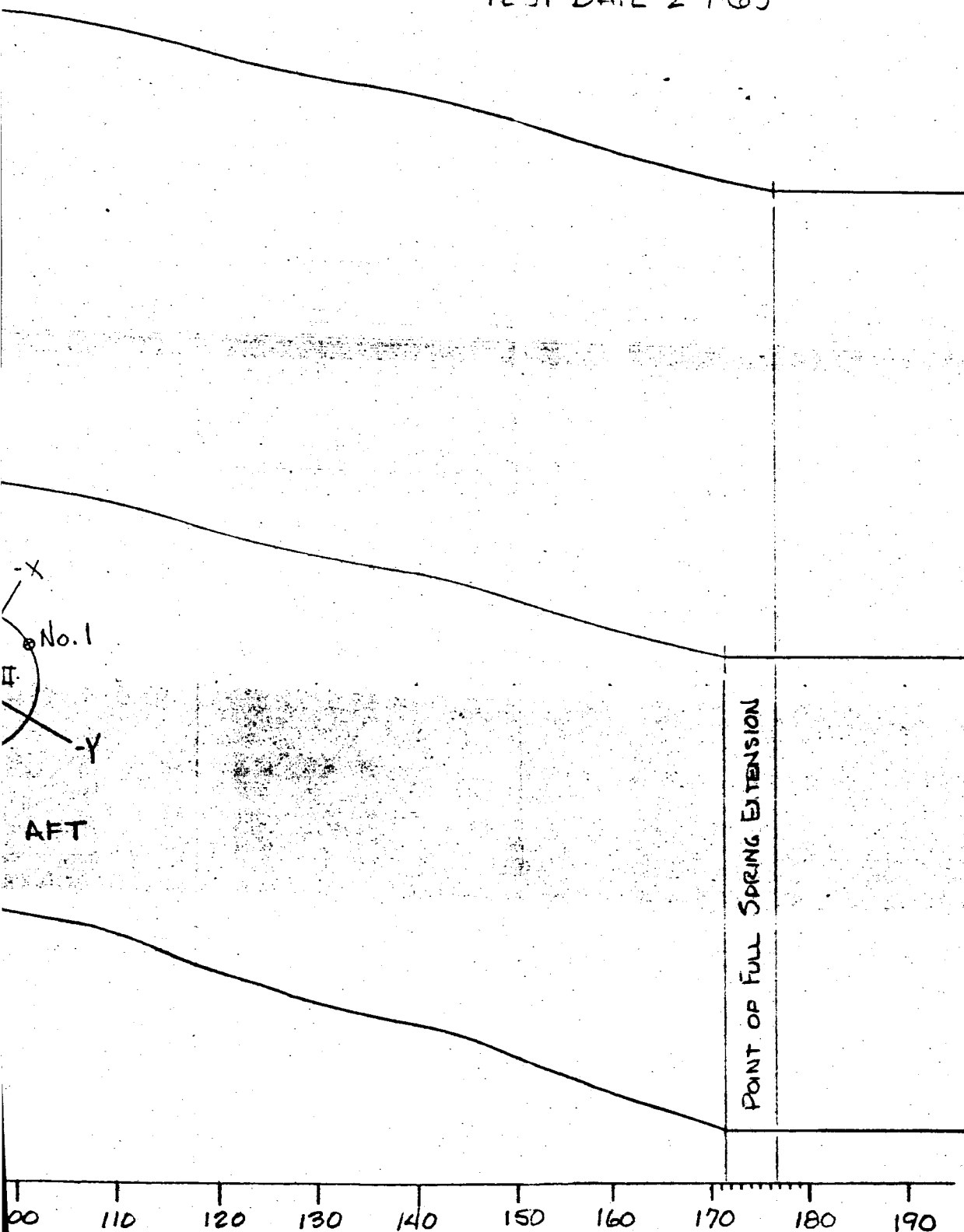
FACSIMILE OF OSCILLOGRAPH DATA - JETTISON SP



NG EXTENSION VS TIME

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TEST RUN No. 1
TEST DATE 2-9-65



POINT OF FULL SPRING EXTENSION

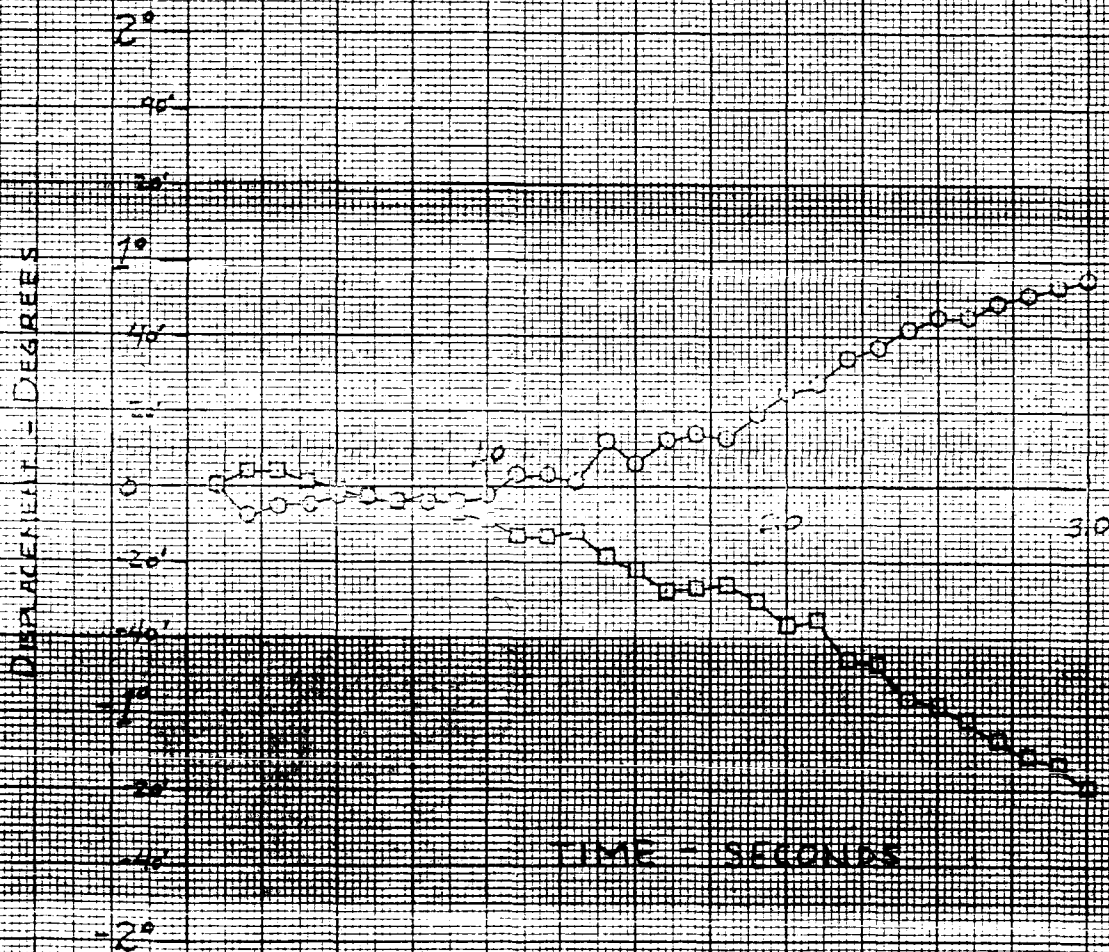
2

FIGURE 7

SURVEYOR SEPARATION TEST

PITCH AND YAW DISPLACEMENT

RUN No. 1 TEST DATE 2-9-65



LEGEND

□ PITCH

○ YAW

X-AXIS IS THE PITCH AXIS

PITCH IN +Y DIR IS (+)

PITCH IN -Y DIR IS (-)

Y-AXIS IS THE YAW AXIS

YAW IN +X DIR IS (+)

YAW IN -X DIR IS (-)

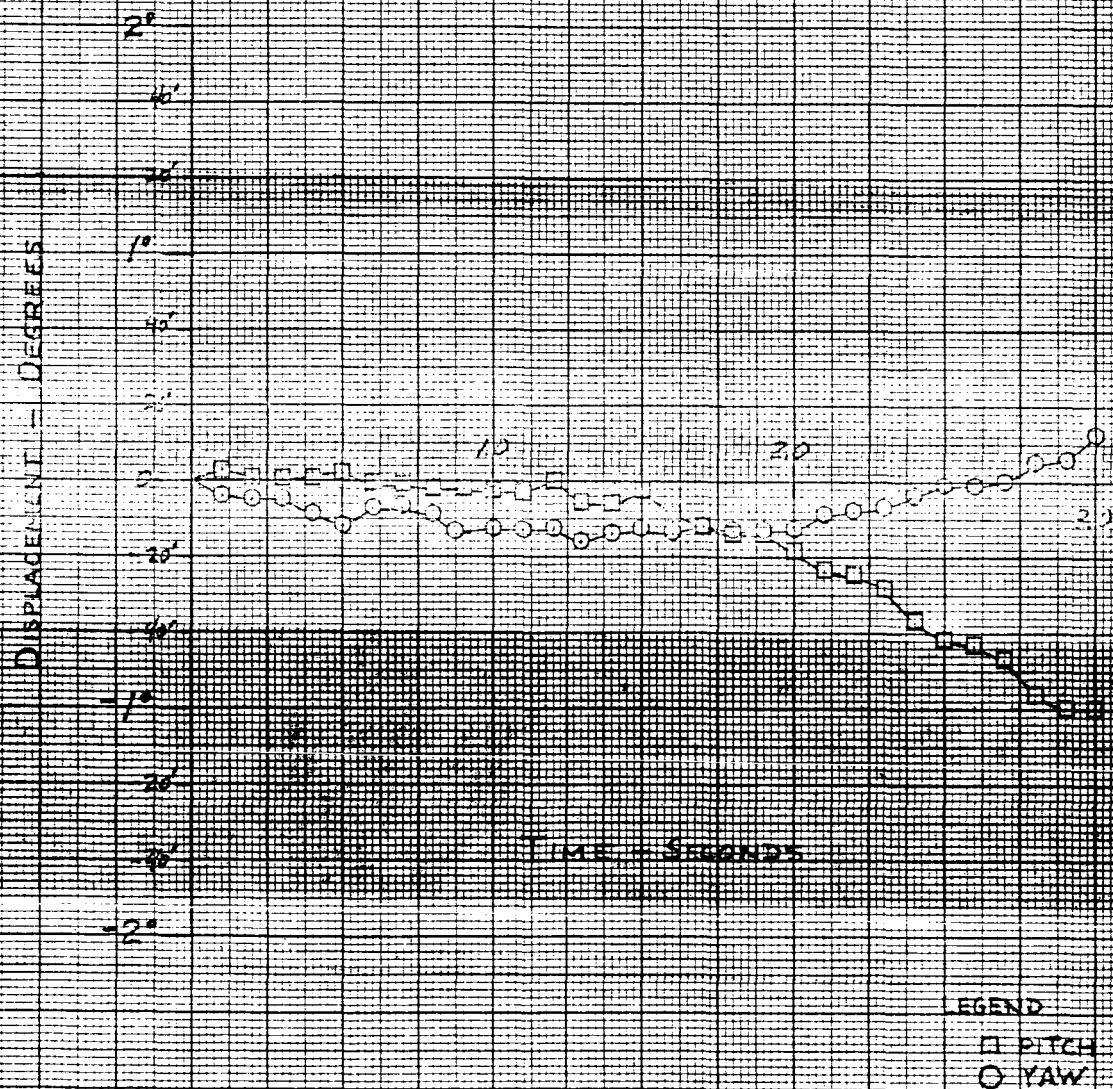
801 2-17-65

FIGURE 5

SURVEYOR SEPARATION TEST

PITCH AND YAW DISPLACEMENT

RUN No 2 TEST DATE 2-11-65



X-AXIS IS THE PITCH AXIS
 PITCH IN +Y DIR. IS (+)
 PITCH IN -Y DIR. IS (-)

Y-AXIS IS THE YAW AXIS
 YAW IN +X DIR. IS (+)
 YAW IN -X DIR. IS (-)

FACSIMILE OF OSCILLOGRAPH DATA - JETTISON SPRING

SPRING EXTENSION - INCHES

SPRING EXTENSION - INCHES

SPRING EXTENSION - INCHES

0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

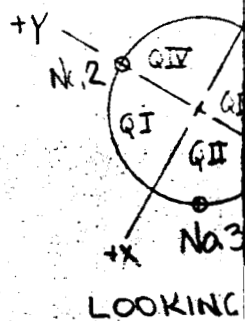
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

SPRING No. 1

SPRING No. 2

SPRING No. 3



0 10 20 30 40 50 60 70 80 90

1

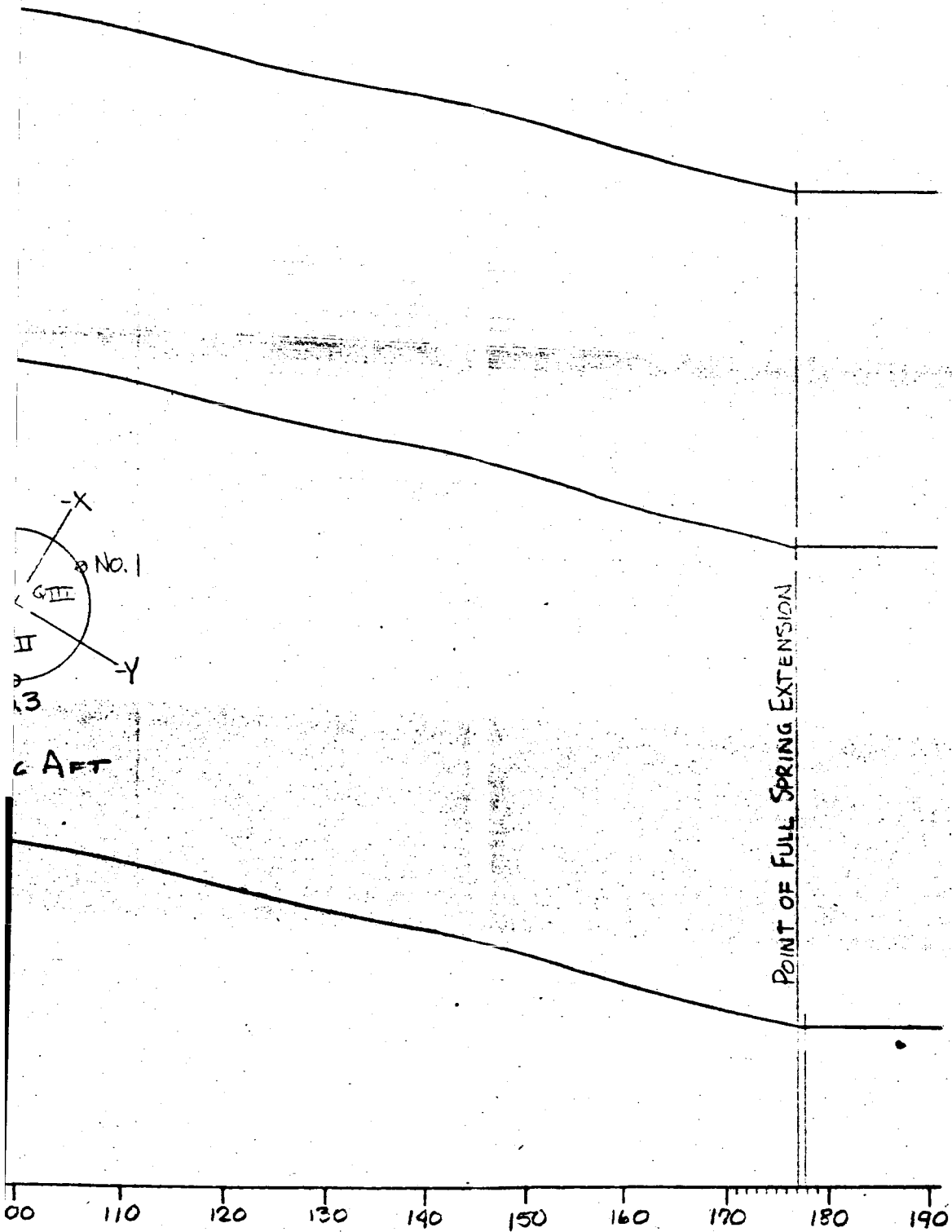
TIME - MILLISECOND

AD. 2-24-65

RING EXTENSION VS TIME

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TEST RUN NO. 2
TEST DATE 2-11-65



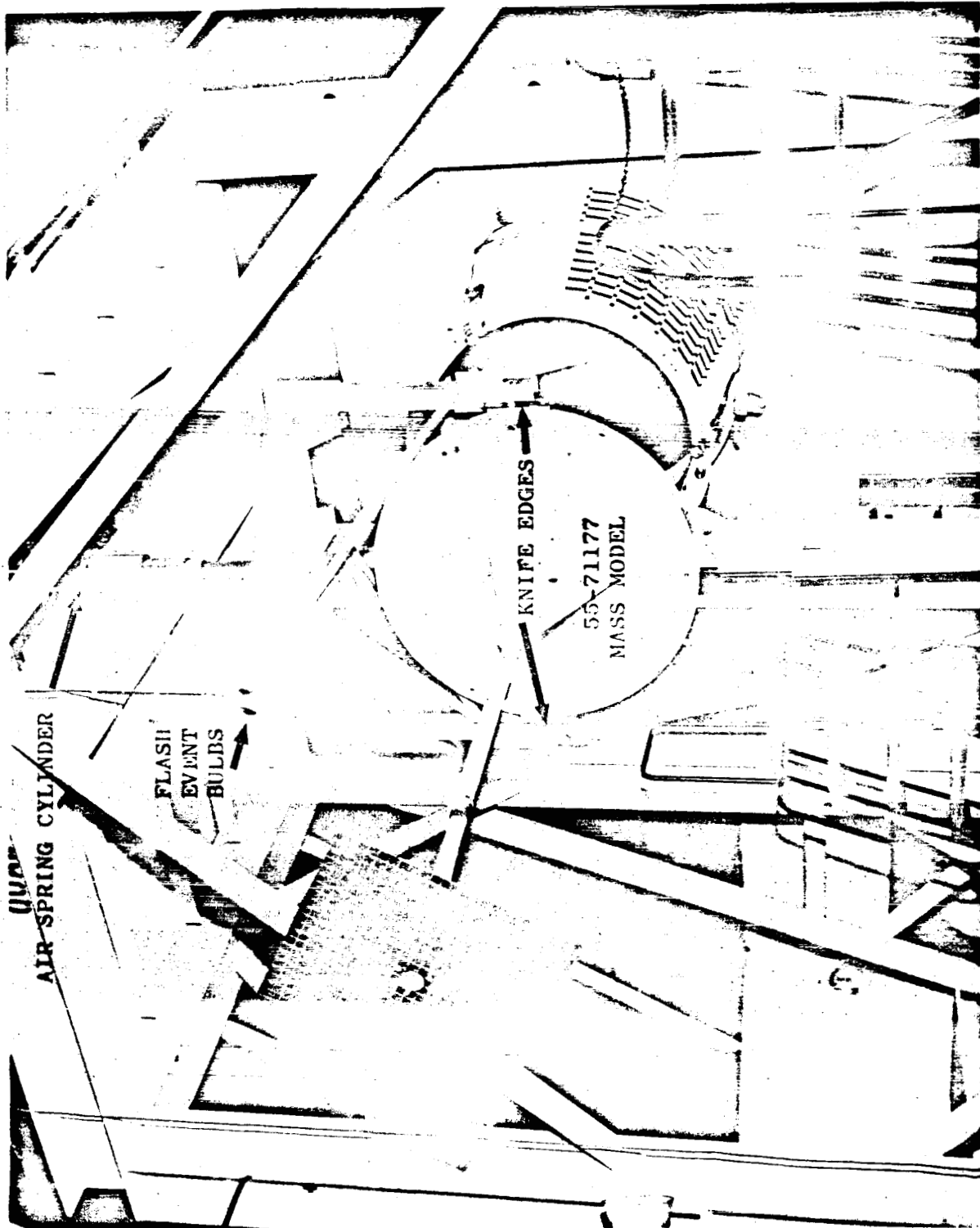
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FIGURE 8

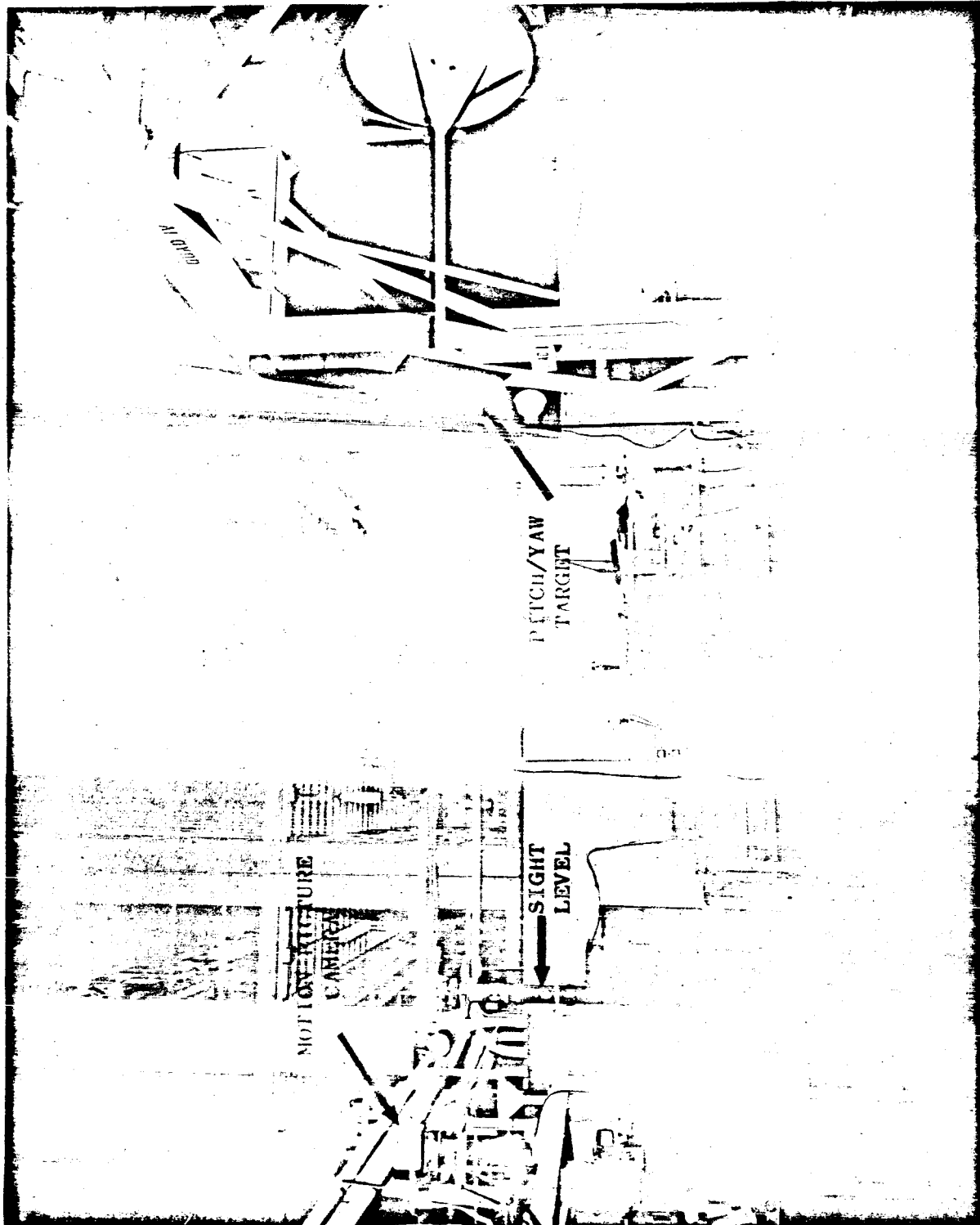
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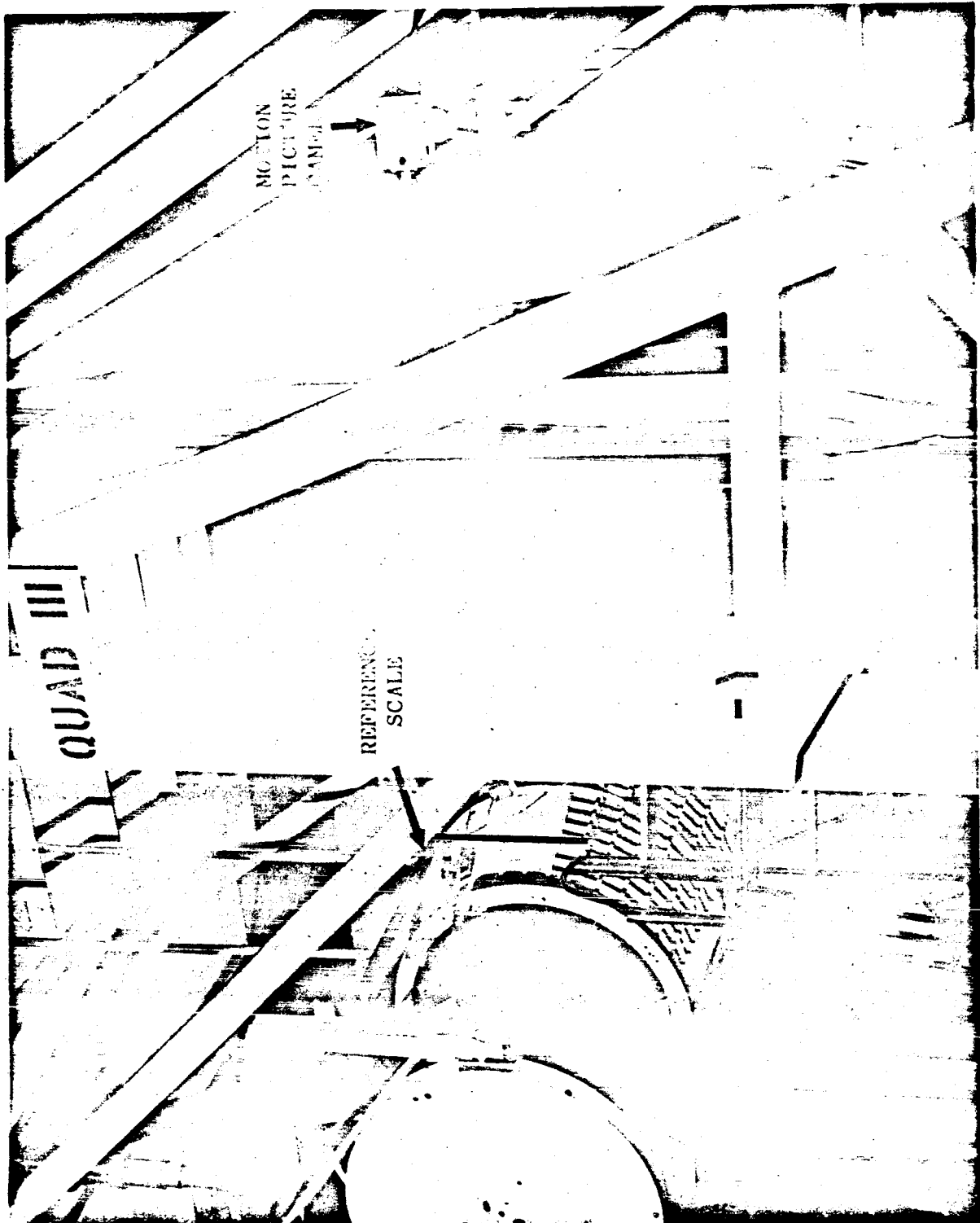
SEPARATION TEST STAND

FIGURE 9



CAMERA SETUP FOR PITCH AND YAW
DETERMINATION

FIGURE 10



CAMERA SETUP FOR SPACECRAFT
DISPLACEMENT DETERMINATION

FIGURE 11

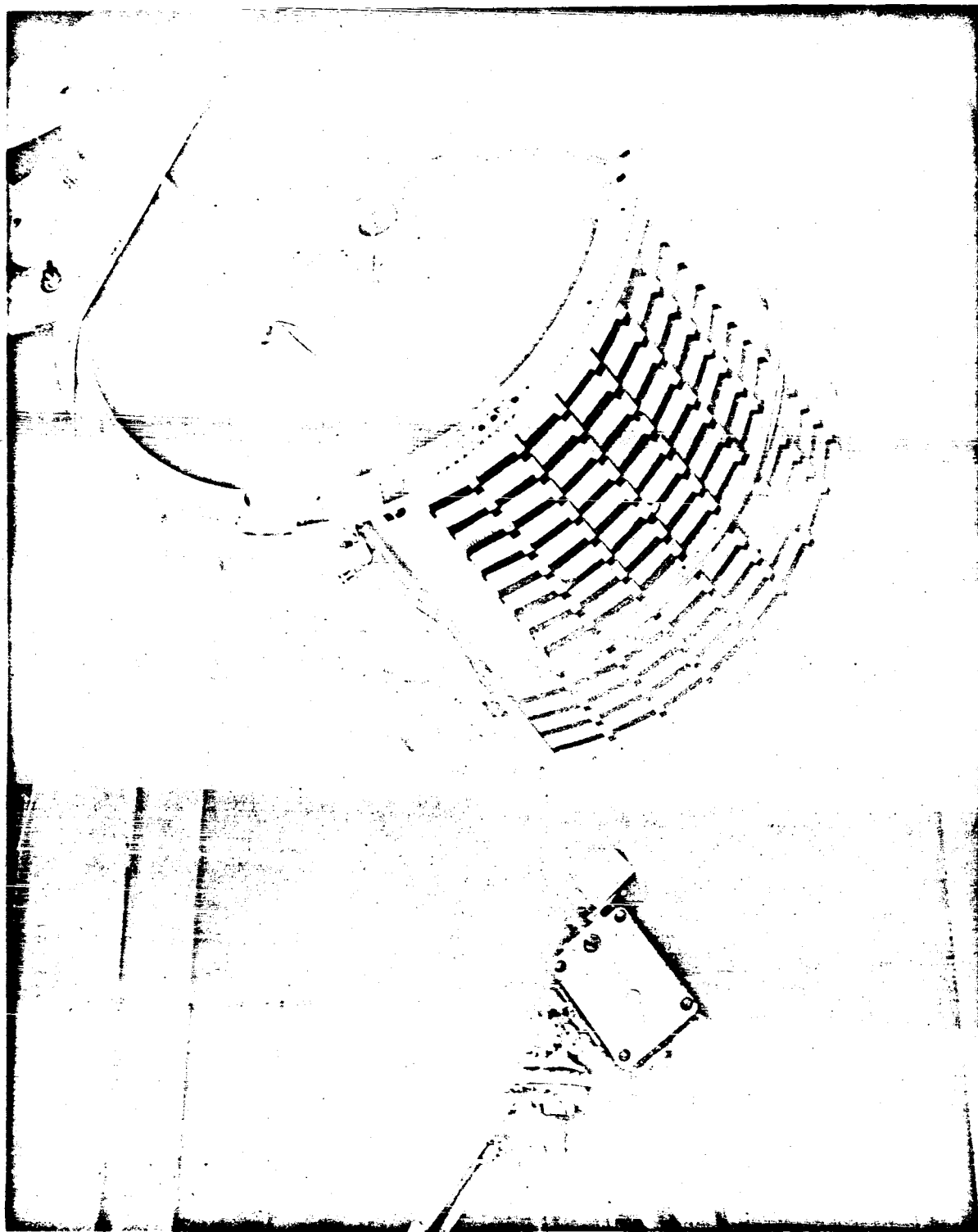
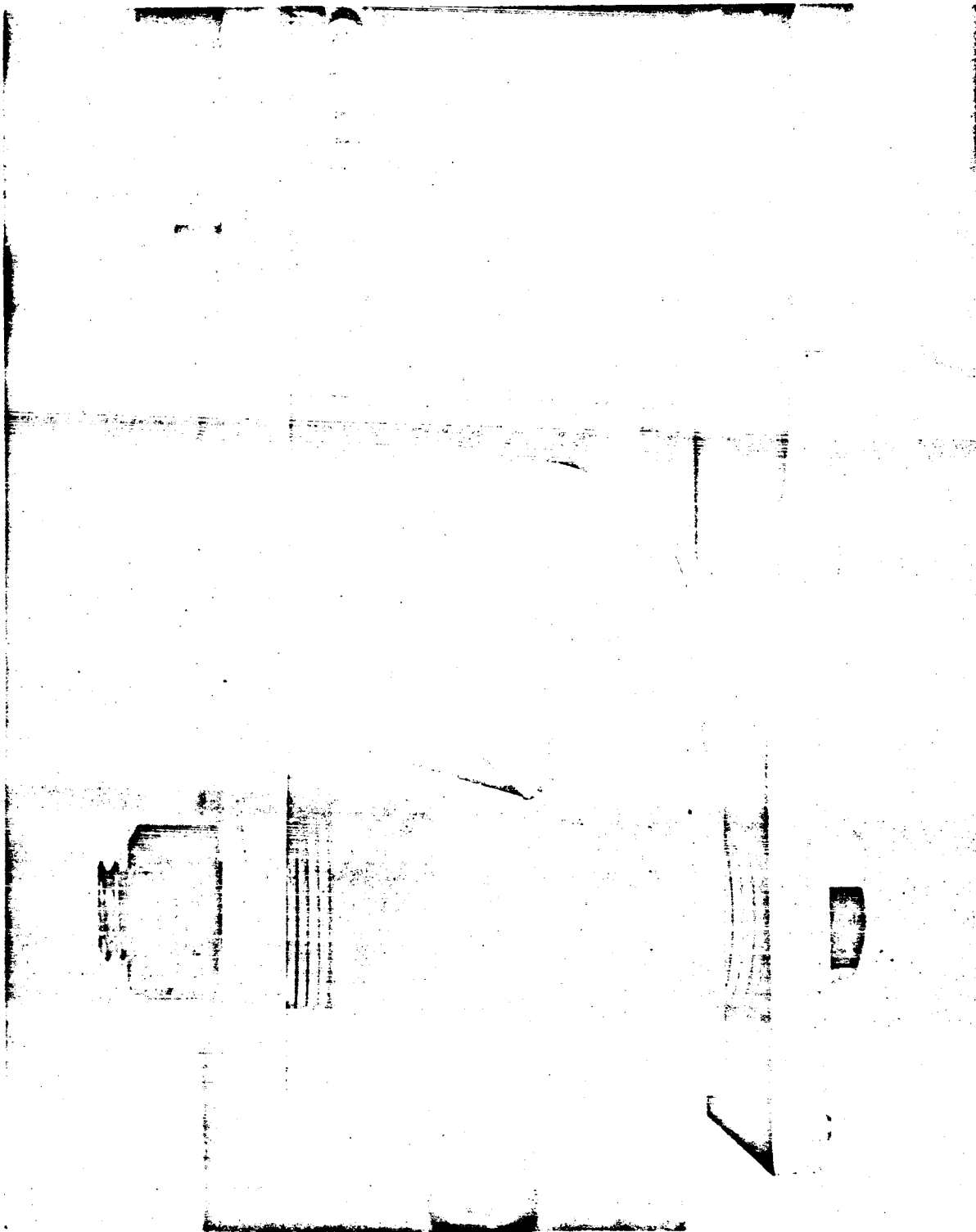


FIGURE 12

CAMERA SETUP TO VIEW LATCH
AND SPRING INSTALLATION



KNIFE EDGE SUSPENSION

FIGURE 13

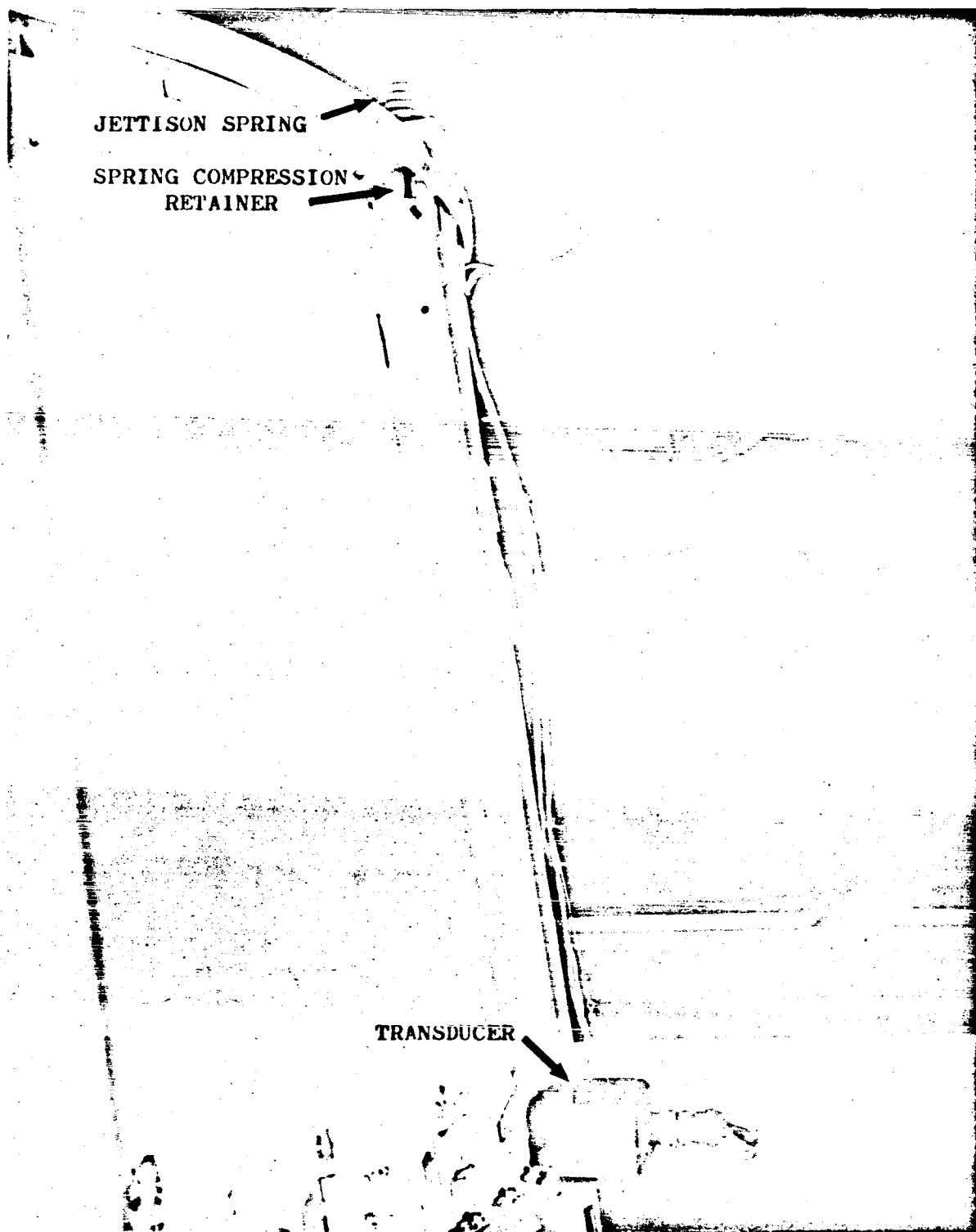
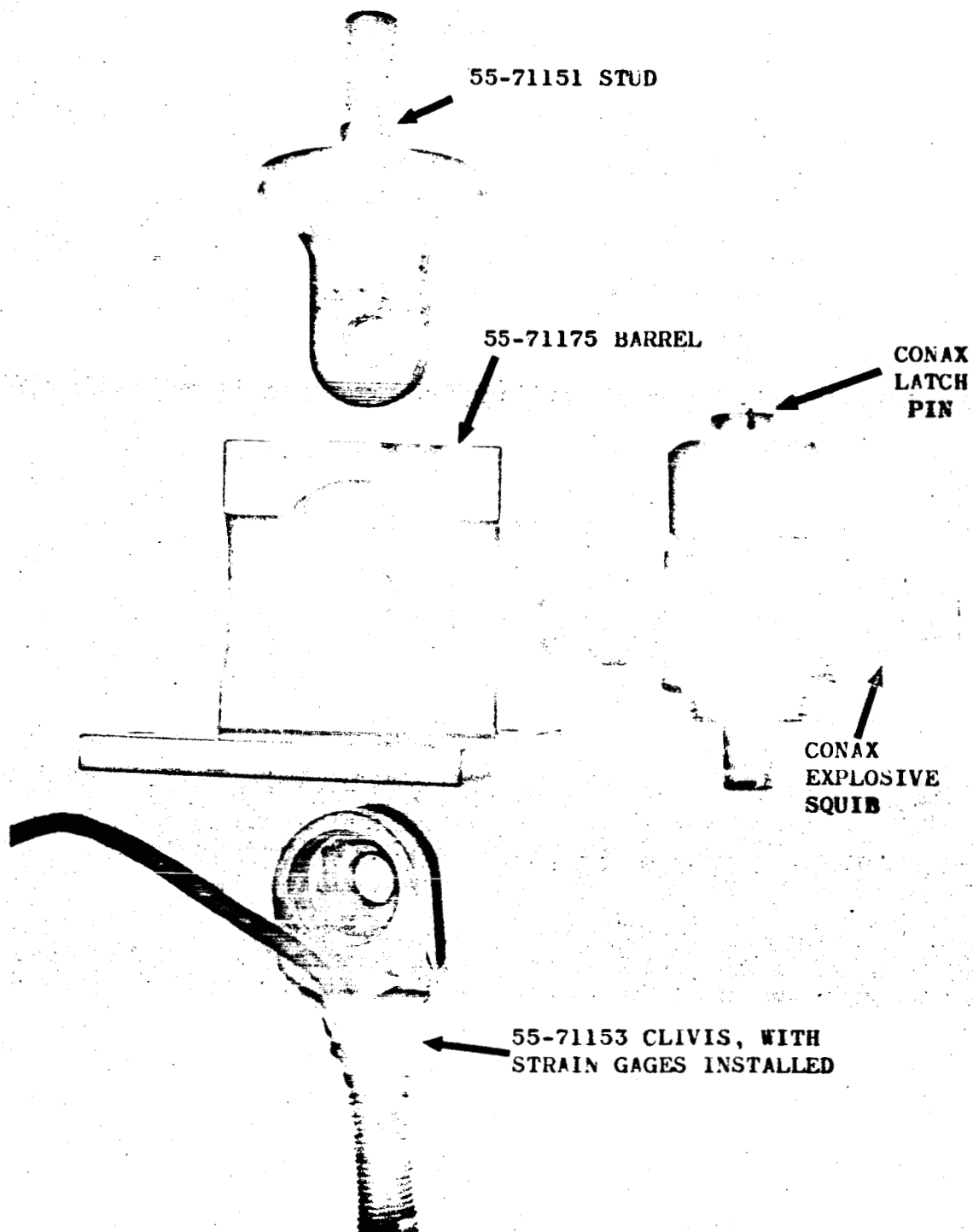


FIGURE 14
LINEAR MOTION TRANSDUCER INSTALLATION
FOR MEASURING JETTISON SPRING DISPLACEMENT



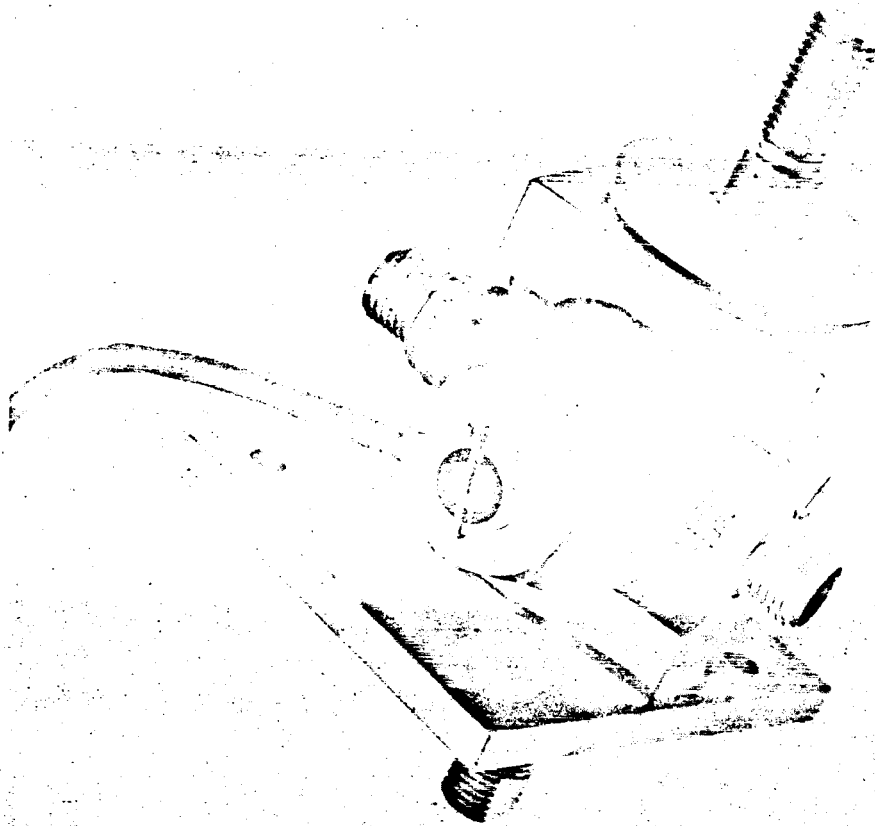
TOOL USED TO COMPRESS JETTISON
SPRINGS

FIGURE 15



55-71190 SEPARATION LATCH COMPONENTS

FIGURE 16



55-71190 SEPARATION LATCH ASSEMBLY

FIGURE 17

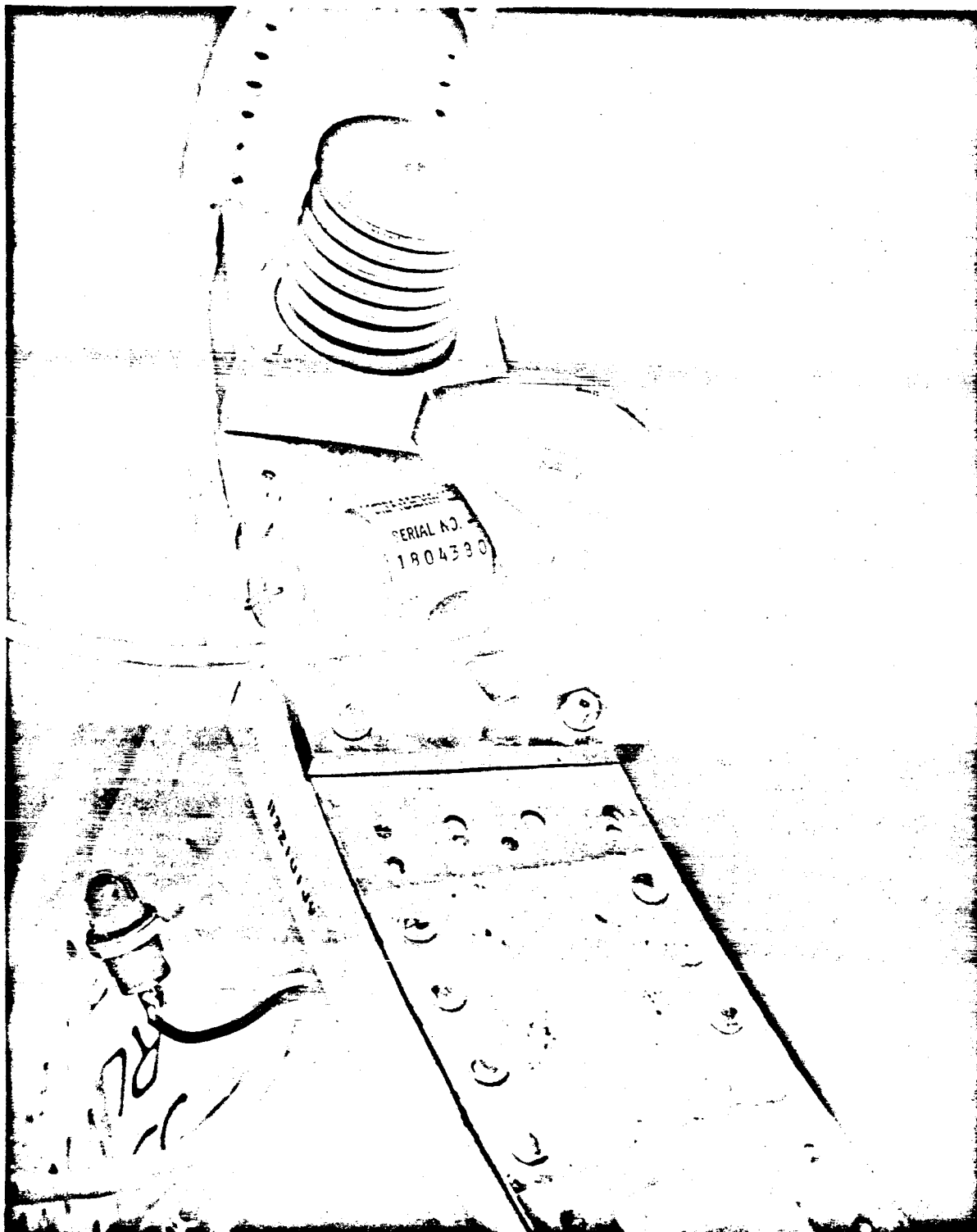
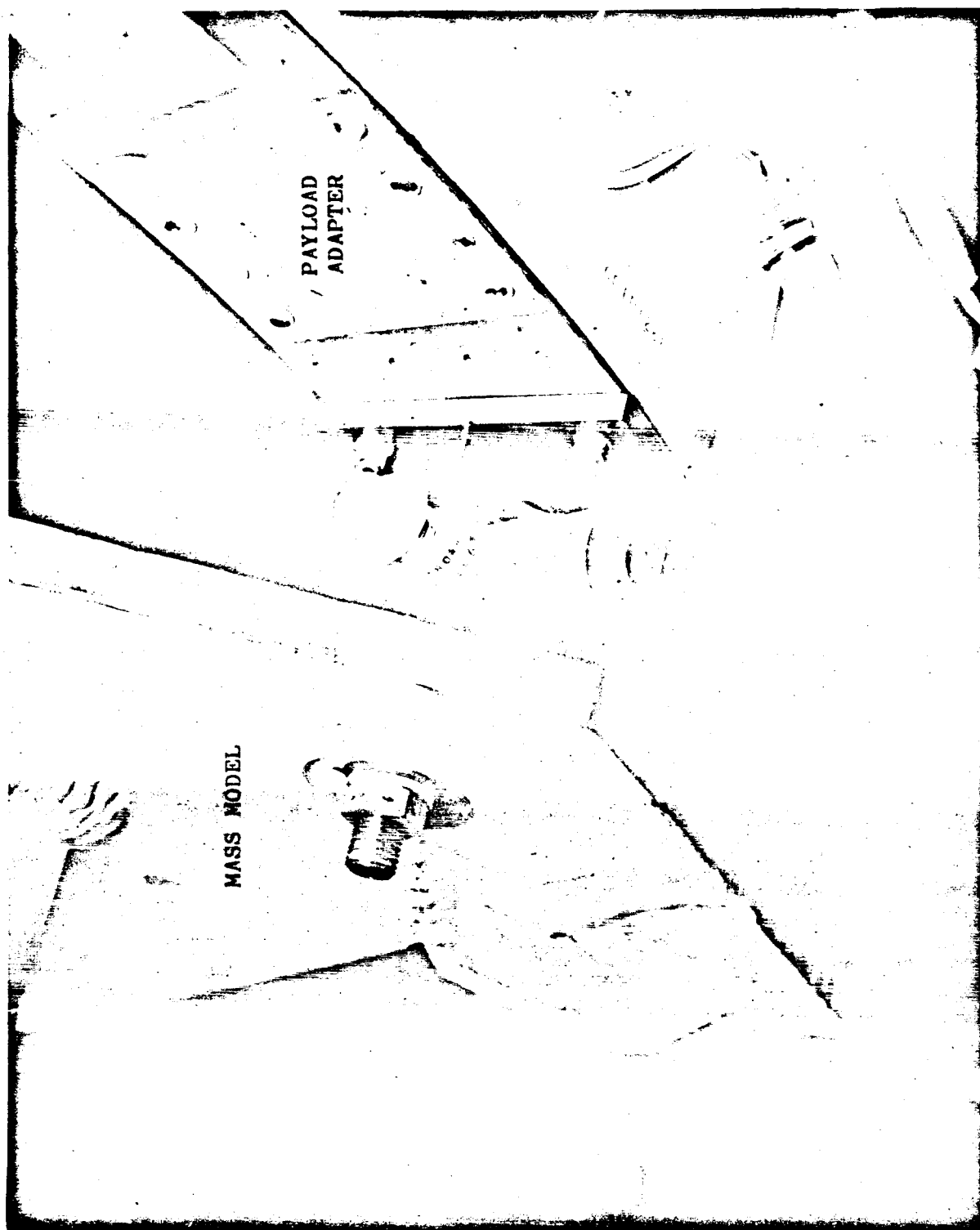


FIGURE 18

SEPARATION LATCH AND JETTISON SPRING
INSTALLATION ON PAYLOAD ADAPTER



SEPARATION LATCH INSTALLATION

FIGURE 19

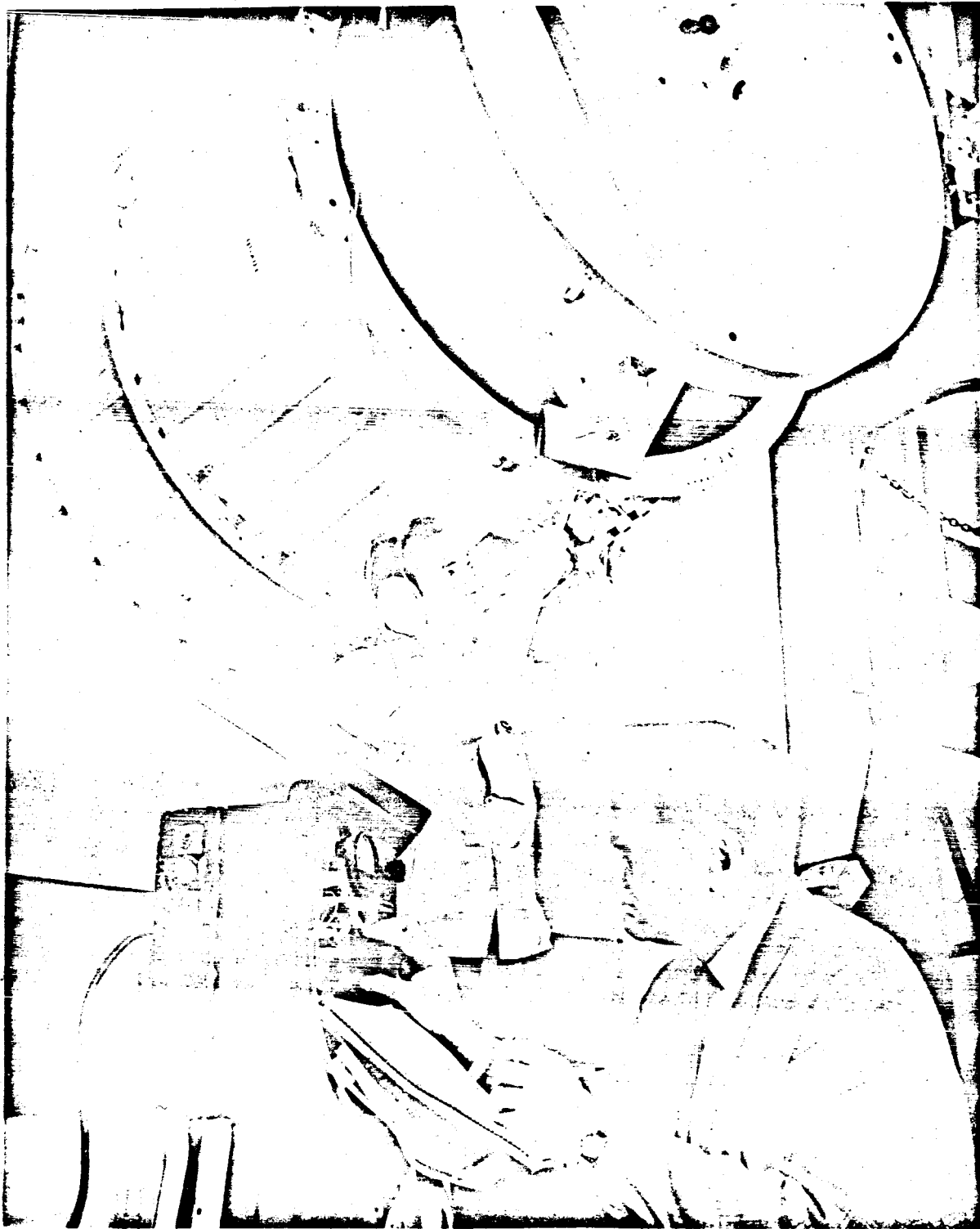


FIGURE 20
SETTING UP OF SEPARATION LATCH PRELOADS